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ABSTRACT

Fewer than 1% of all practicing scientists are Hispanics. In engineering, Hispanics represent only 3.2% of all full-time students, 1.2% of all masters students, and .7% of all doctoral students. Hispanic underrepresentation in engineering and science results from several factors. These include, at the high school level, recruitment and career exposure programs that do not consider minority cultures; counselors who unconsciously reinforce established Anglo and Hispanic career patterns; science curricula that inadequately prepare students for college science and engineering programs or that are too abstract; and teachers who are underutilized as resources and role models. An intervention model, such as that developed by Scott, can help provide the early corrective action necessary to promote Hispanic representation in technical fields. Also, secondary schools should reorganize science curricula around everyday science, provide bilingual science and math instruction, and improve counseling. Colleges should support special minority programs in fields such as engineering, sciences, and math, and should actively recruit Hispanics for their programs. Graduate and professional institutions should provide adequate financial aid, develop post-baccalaureate programs for Hispanics, and include a multicultural focus in their technical programs. National-level emphasis on needs, programs and funding for Hispanic involvement in math and science is recommended. (SB)

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Hispanics, Engineering and the Sciences: A Counseling Guide

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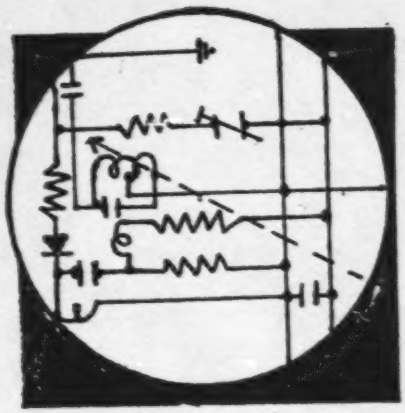

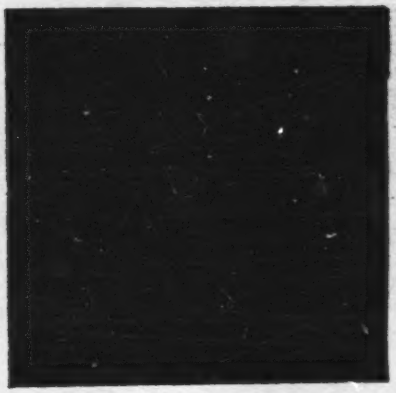

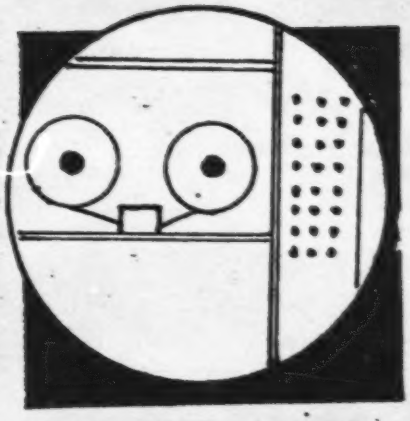

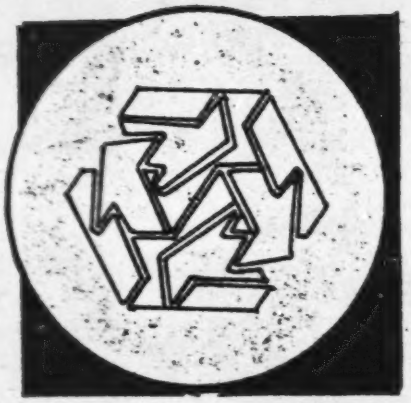

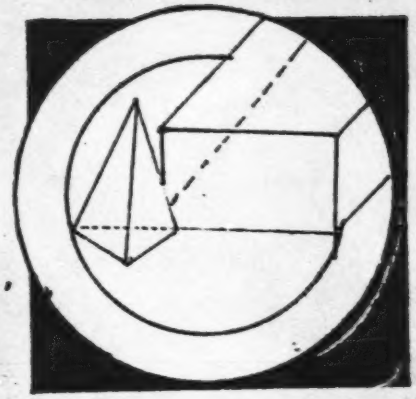

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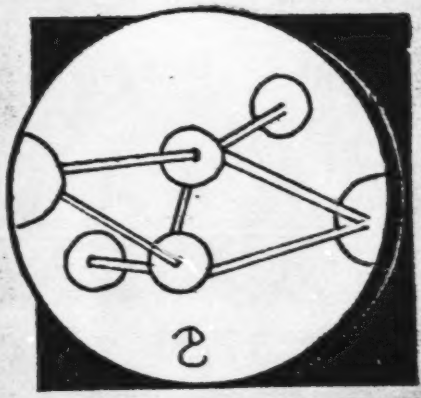

ERIC

HISPANICS, ENGINEERING, AND THE SCIENCES:

A COUNSELING GUIDE

by

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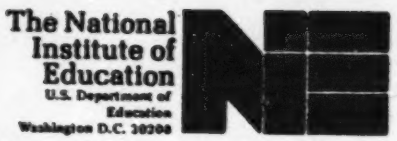

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STATEMENT OF THE PROBLEM

Numerous studies have documented the educational and economic neglect Hispanic Americans have suffered during the past 200 years. The reasons for such neglect are complex. The residue of hatred, discrimination, and deprivation have left large wounds among Hispanics, and these wounds are far from healed. While Hispanics have generally made great strides in the last 25 years, they are still underrepresented in every area of professional development. However, notably lacking in Hispanic representation are the fields of science, engineering, and technology. For example, Hispanic science doctorates number less than one percent of the total science doctorates.

Both the minority and the dominant cultures can benefit from increasing the number of Hispanics in these areas. Because science plays such an important role in shaping our environment and society, minorities must participate fully in scientific activities to achieve total integration into and influence upon the dominant power structure. On the other hand, the dominant culture needs the talent and genius which lie in all its racial and ethnic groups.

Since the dominant society has recognized the severe paucity of Hispanic scientists, institutions and foundations have set goals to rectify the situation. However, even if the number of Hispanic scientists were to double by the end of the 1980's, the resulting two percent is hardly enough to be morally or pragmatically earnest. This superficial goal can be achieved without examining the root of the problem, which is the great cultural divide between the dominant and minority societies. Although both groups want to increase the supply of Hispanic scientists, the failure to consider cultural differences has thwarted efforts to reach their common goal. Bridging the gap between the

two cultures lies in a delivery system that is founded on data that deals with what is, rather than with what ought to be. This effort to increase the supply of Hispanic scientists must include the development of a realistic, supportive services model.

INTENT AND DIRECTION

The present study examines the status of Hispanics in the sciences, engineering, and technology. While documentation of status is important, the real need is to improve conditions. What, exactly, needs to be done to increase the number of Hispanics in these increasingly important fields? Present conditions and possible changes are presented for the following aspects of career development:

... Recruitment and career exposure

... Counseling

... Identity with role models

... Curricular changes

... Teacher roles

... Professional opportunities

Most importantly, the recommendations focus on needs at three levels: (1) precollegiate, (2) collegiate, and (3) graduate and professional training. The recommendations are not all inclusive and are not intended to be. Rather, the intent is to give direction to the effort to increase Hispanic representation in the sciences, engineering, and technology.

BACKGROUND

The economic deprivation of Blacks, American Indians, and

Hispanics is well documented. This deprivation constitutes the primary reason for the low number of minority members in the technical areas. An understanding of economic deprivation, and its resultant educational deprivation, gives direction to understanding the absence of Hispanics in technology.

Researchers have shown that the pursuit of science is strongly influenced by personality variables. Studying 64 eminent scientists, Roe (1952) found that most scientists were loners, uncomfortable in social settings, and preferred to work with things rather than people, and that although knowledge was valued for its own sake, scientists were intensely motivated by the need to master or control their environment and to satisfy their own curiosity. However, the inner city or remotely rural environment from which Hispanics come, and the psychological framework within Hispanic communities, have not been conducive to the development of such traits. One cannot, therefore, ignore the possibility that the displaced need for assertion and control has a direct bearing on the fact that so few Hispanics pursue scientific endeavors. Obviously, youth whose psychic energies are absorbed by the exigencies of daily survival have little energy to satisfy intellectual curiosity and to pursue knowledge for its own sake.

Moreover, the different frames of reference which characterize Hispanic and Anglo cultures further compound the problems of developing a satisfactory relationship with the system. The dominant culture operates from a cognitive perspective in which the prestige mode of communication is visual-mental. On the other hand, the Hispanic culture, it seems, operates from an affective vantage point, in which the prestige mode of communication is aural-oral (Green and Brown, 1976). Such a difference conditions one's learning styles as well as one's preference for various disciplines.

It must be remembered, however, that science, as a concept, is not foreign to Hispanics. American Indians and Hispanics practiced basic scientific principles long before the Anglo conquest of the southwestern United States. The use of plants and herbs for medication, the arrival at an effective relationship between man and his environment, and the development of tools for achieving designated goals (technology) are inherent in Hispanic culture. American education, generally speaking, has denigrated and demeaned these roots as anthropological "curiosities," and the developmental process by which this "science" and "technology" originated has never been explored. More importantly, the psychological and cultural framework--so important to curriculum design--that was instrumental in the development of these concepts remains unexplored. The technological advancements of these peoples came during an age when they "controlled their destiny." The discoveries and explorations were for the betterment of <u>their</u> society. The importance of this psychological foundation cannot be overemphasized. When culture is free to prosper, exploration and discovery are a natural phenomenon.

If one adds to this destruction of the Hispanic culture's scientific foundation, the lack of role models for Hispanic youth to emulate and the inadequate curriculum of many inner city and rural schools, a comprehensive picture of the factors working against Hispanic participation in science and technology is visualized. Against such a background, the exposure to science and engineering programs and the financial aid making it possible to enter them hardly scratch the surface.

HISPANICS IN TECHNOLOGY

As indicated above, less than one percent of all practicing scientists

and engineers are Hispanics. Sadly, the numbers do not seem to be increasing despite the efforts of various private and public organizations. Table 1 is a composite of graduate minority student enrollment at 154 colleges and universities in 1978. The table presents total enrollments in each designated professional area, as well as percentages of those students who are of Black, Hispanic, American Indian, and Asian ethnic heritage.

The critical factors observed in Table 1 are the shamefully low percentages in the categories of "Life Sciences" and "Physical Sciences." Generally, 6.2 percent of all life science graduate students are Hispanic. The numbers are even more depressing when the areas of biology, biochemistry, microbiology, and physiology are isolated. Hispanic graduate students, in each individual area, amount to less than one percent. The physical sciences fare just as poorly among Hispanic graduate students in the universities studied. Only two percent of those enrolled were Hispanics studying mathematical sciences. Additionally, chemistry and physics display less than two percent Hispanic enrollments. Thus, Table 1 verifies previously stated information. In the 154 institutions examined, the largest enrollments of Hispanics are found in the arts, humanities, and education.

Sheridan (1979) looked at more than 300 engineering colleges (as compared to 154 in the study summarized in Table 1) which offered baccalaureate or higher degrees. Table 2 depicts the enrollments of women and minorities (including Hispanics) in undergraduate engineering programs. Notably, Hispanics comprise a very low percentage of the students enrolled in years one through four. The most striking figure, however, comes under the category "Fifth Year Student." A surprising 14.8 percent of the students working for the fifth year on a baccalaureate degree were Hispanics. Sheridan (1979)

Table 1. Enrollment of Minority Graduate Students: Percentage Distribution by Field of Study[1]

Field of Study[3]	Total Enrollment	Minority Enrollment[2]			
		Black	Spanish-Surnamed	American Indian	Asian American
Arts & Humanities	53,920	9.3	19.9	13.9	9.5
Education	96,568	43.0	27.9	32.5	11.6
Engineering	31,273	2.3	6.6	3.1	20.1
Health Professions	13,238	4.5	4.1	6.4	5.1
Life Sciences	27,641	2.6	6.2	5.3	10.2
Biology	(5,027)	(0.8)	(0.9)	(0.3)	(1.7)
Biochemistry	(1,004)	(0.1)	(0.3)	(0.4)	(1.1)
Microbiology	(1,001)	(0.2)	(0.4)	(0.5)	(1.1)
Physiology	(1,110)	(0.1)	(0.3)	(0.3)	(0.4)
Other	(13,504)	(1.2)	(3.6)	(2.9)	(5.0)
Mathematical Sciences	12,446	1.9	2.0	2.0	5.2
Physical Sciences	21,629	1.8	3.5	4.2	11.1
Chemistry	(8,040)	(0.8)	(1.3)	(1.3)	(5.0)
Physics	(5,559)	(0.4)	(0.8)	(1.0)	(3.3)
Other	(6,560)	(0.5)	(1.1)	(0.9)	(1.9)
Basic Social Sciences	35,583	9.1	10.7	9.3	7.5
Economics	(5,766)	(0.7)	(1.2)	(1.3)	(1.8)
Psychology	(10,313)	(2.7)	(3.0)	(2.5)	(1.7)
Sociology	(4,566)	(1.6)	(2.2)	(0.9)	(1.2)
Other Basic Social Sciences	(12,969)	(3.7)	(4.1)	(4.2)	(2.6)
All Other Fields	80,666	25.5	19.3	23.4	19.7
Total, All Fields	372,964	100.0	100.0	100.0	100.0

[1]Table appears in Sie, M., Minority groups and science careers, Integrated Education, 1978, 16(3):43-46.

[2]Based on data from 154 institutions able to provide minority enrollment data within field of study.

[3]Figures in parenthesis sum to less than their respective subtotals because some institutions could report only for the total field category but not for subfields.

Table 2. Undergraduate Engineering Enrollments: Women, Minority Groups, and Foreign Nationals, Fall 1978*

Minority Group	Undergraduate Students						
	First Year	Second Year	Third Year	Fourth Year	Fifth Year	Total Full-Time	Total Part-Time
Women	12.3%	11.7%	10.6%	9.4%	8.2%	11.1%	6.2%
Black	5.7%	4.3%	3.3%	2.7%	3.5%	4.7%	3.2%
Hispanic	3.4%	2.8%	2.8%	2.6%	14.8%	3.2%	2.5%
Asian/Pacific	2.2%	2.7%	3.1%	3.1%	2.7%	2.8%	1.7%
American Indian	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%	0.3%
Foreign National	-----	-----	-----	-----	-----	-----	-----
Total, All Students	100%	100%	100%	100%	100%	100%	100%

*Table appears in Sheridan, P.J., Engineering and engineering technology enrollments, Fall 1978, Engineering Education, 1979, 70:58-66.

does not give any reasons for this fact. It may be assumed, however, that Hispanics have a more difficult time completing engineering programs in four years. Perhaps economic and social conditions are an important factor in forcing a fifth year of studies on these students.

Equally striking in Table 2 are the data that indicate "total enrollments" of Hispanics in baccalaureate engineering programs: just over three percent of the enrollment are full-time Hispanic students. Only the small percentage (less than one percent) of American Indian "full-time students" is more striking than that of Hispanics.

At the graduate level (masters, doctorate, and engineering specialists degrees), the figures are even more damaging. Table 3 shows Hispanics comprising only 1.2 percent of the students enrolled in masters degree programs; a slightly better 3.6 percent in engineering specialists programs; and an abysmal .7 percent in doctoral programs. Little wonder, then, that Hispanics comprise only about one percent of all graduate engineering enrollments.

The issue, therefore, revolves around ways and means to stem the tides of educational disservice to the Hispanic community in the areas of the sciences, technology, and engineering. Extensive changes are needed at specific levels of American education, and critical areas are examined and analyzed in subsequent discussion.

Recruitment and Career Exposure

Recruitment should be considered in an all-inclusive manner. Such an approach requires identifying the target group, informing this group, motivating its members when and if necessary, and doing whatever else is needed to entice them into the sciences, technology, and engineering.

Table 3. Graduate Engineering Enrollments: Women, Minority Groups, and Foreign Nationals, Fall 1978*

Group	Minority Enrollment				
	Masters Degree	Eng.Spec. Degree	Doctoral Degree	Total Full-Time	Total Part-Time
Women	8.8%	8.6%	5.2%	7.6%	5.4%
Black	1.3%	3.7%	0.8%	1.2%	1.6%
Hispanic	1.2%	3.6%	0.7%	1.1%	1.3%
Asian/Pacific	4.0%	4.1%	4.0%	4.0%	4.0%
American Indian	0.1%	0.0%	0.1%	0.1%	0.1%
Foreign National	28.0%	33.1%	3.5%	30.0%	9.8%
Total, All Students	100%	100%	100%	100%	100%

*Table appears in Sheridan, P.J., Engineering and engineering technology enrollments, Fall 1978, Engineering Education, 1979, 70:58-66.

If this sounds like a big job, it is. Good selective recruitment can help to ensure successful completion of training by enabling solution of many retention problems.

In her work on health careers for Blacks, Russell (1976) relates the following:

> Several years ago a survey revealed that Alabama ranked 47th of all states in numbers of trained health personnel and in availability of health care. Based on the 1970 census, Alabama has 70 black physicians, 26 black dentists, and one black optometrist. Realizing the importance of career and counseling for minorities, Alabama's school of community and allied health resources in 1972 developed and implemented, through HEW's Health Resources Opportunity, a program called Project Black Awareness-Health Careers. Project Black Awareness arose from this need for more black health personnel and professionals in Alabama. (p. 33)

In another section of that article, Russell states:

> A primary goal of the project (Black Awareness-Health Careers) is to inform the target population of the opportunities in health careers by disseminating health careers information. This entails explaining relevant points about the health care system, and motivating students by showing them black graphics geared to their interests, providing tours of the university medical center complex, and facilitating general rap sessions. (p. 34)

As implied by Russell (1976), young blacks (and Hispanics) are like the eagle in the old fable. The eagle was told for a long time he was a chicken, and, after awhile, he believed it. Young Hispanics have been told for so long that they are not smart enough for medical school or for one of the other science areas that they have come to believe it. So, much effort must be expended to dispel the old myths--myths such as science and engineering are only for child geniuses. Realities must replace these myths.

Many of today's Hispanic students are first-generation college students. They have few ideas as to what to expect, either from college or from a career in a technical area. Active recruitment of Hispanic students for technical programs is necessary because minority students traditionally do not enter these programs after they graduate from high school. Such students are not aware of the minority persons who have experienced success in these fields. They may be aware of one Hispanic doctor or nurse, but seldom have they seen a Hispanic scientist or engineer. Further, they have little idea of the high school background needed to enter such programs. They do not know how many years of study are required to complete these programs, and perhaps, most importantly, they are skeptical of the available job opportunities once they complete such programs (Barbosa, 1975).

A program to recruit Hispanic students for technical programs must provide information regarding high school background needed, composition and duration of programs, and job opportunities. Such information must be

ample in supply and varied in form. Colorful and interesting brochures, large posters, reply cards, special curriculum activities, actual examples of minority persons (especially Hispanics) who have been successful in these fields, short films and slide presentations are all effective ways of communicating with Hispanic students (Aronson, 1976).

It is not sufficient to have adequate information about technical programs available; it is vital that this information be shared with Hispanic students. This is often difficult because some high school counselors feel that few minority students are able to do college work. Consequently, these teachers do not share information concerning college programs as completely with minority students as with other students. The debilitating experiences that many Hispanic students have had makes them reluctant, in many cases, to ask teachers and counselors about available programs of study in higher education institutions (Aronson, 1976).

For effective recruitment of Hispanic students, personal representation of various technical areas must directly contact the students, both in groups and individual encounters. Representatives or recruiters must be resourceful in making arrangements to meet with Hispanic students wherever they can get to them. Sometimes this can be done in a formal high school setting by contacting a counselor. Sometimes, though, it is difficult to get counselors to understand why you wish to meet with certain groups of students. Often, counselors say, "We had our college night last month. We don't let anyone talk to students other than at that time." There are also those counselors who "forget" to make the announcement until you arrive. There are other counselors who state, "We have polled our students and there is no one here who wants to talk to you."

All counselors are not insensitive, though. There are many who are very interested in minority students and really work to help them. Generally, however, there are more of the former (counselors) and few of the latter (Morris, 1976).

It is imperative that resourcefulness be used in getting information about technical programs to Hispanic students. Knowing the principal or assistant principal can often open doors. A concerned Hispanic or other minority teacher in a school can work wonders. If all these efforts fail, however, and students cannot be seen in school, only the battle is lost--not the war. The recess or lunch periods are often good times to make contact.

Quite often, it is necessary to arrange meetings with students outside of school. Informal chats or receptions held for Hispanic students may be effective if they are held at some place in the student's neighborhood and are well advertised. Minority students should not be expected to go to the tenth floor of the Hilton to hear a representative talk about an engineering program. More often than not, students will not show up. Visiting the homes and churches of Hispanics (and other minorities) may also be a way of making contact with the students.

A good recruitment program includes bringing students to the source of training. Many minority students have no idea what is involved in training to be a medical technologist, or a biologist, or a chemical engineer. Being allowed to see the equipment used, to hear instructions given, and to observe other students working may help a student decide that this is just the thing for his/her life's work (Cussler, 1978).

Another factor that might play into successful recruitment of Hispanics deals with language. While the minority of Hispanic students today

speak English, a Spanish-speaking recruiter may not be a bad idea. The intent here is to show students that the recruiter is "one of them"--an individual whom they might trust.

To be really effective, recruitment of minority students should begin as early as the high school sophomore year and certainly must begin no later than the junior year. Students must begin to consider college early in high school and take the special courses needed to enter a particular program.

Counseling

Although counselors and teachers have shown general awareness of expanding career opportunities for minorities in the sciences, their awareness was primarily based on the knowledge of affirmative action programs and recognition of a growing global awareness that the sciences, like many other employment areas in which Hispanics are underrepresented, are making attempts at correcting these deficits.

Aiken (1969) reports that school personnel feel most knowledgeable and most capable of apprising students of career opportunities in the health care fields. Ironically, engineering and sciences other than health and health-related fields are the ones which show the most glaring absence of minorities and, consequently, are the ones in which the greatest motivating and recruiting efforts should be made. Yet, counselors and teachers state that their general knowledge of career patterns in the sciences is lacking, especially since this is an ever-changing area in which new jobs and specialties are opening up constantly. Consequently, they feel severely limited in the type and amount of information they can pass on to students generally and minority students specifically.

Aiken (1969) emphasizes the need to apprise counselors of career opportunities for minorities in the sciences. Corporations, foundations, and other organizations which recognize the disparity regarding Hispanics (and Blacks) in the scientific fields need to stimulate redress in this area by funding or initiating activities designed to keep science teachers and counselors abreast of the rewards for Hispanics in the scientific fields.

With regard to counseling practices, George and Dietz (1971) indicate that counseling practices of Anglo counselors seem to differ somewhat from those of minority counselors when minority students are involved. The counseling practices used to encourage minority students to explore science careers differed little from those used for other students. Where interest was shown, counselors generally did everything possible to encourage students to pursue science careers. They state, "Generally, the counselors felt that minority students were recommended to follow science careers as often as Anglo students. However, they readily admitted that a disproportionately small number of minority students take advanced science courses" (p. 527).

Anglo counselors tend to feel that targeted counseling is a disservice to all students. If anything, Anglo counselors, through benign neglect, permit students to follow short-term goals, often ending in low-paying, dead-end jobs. Moreover, Anglo counselors who do not view the sciences as obvious fields of endeavor for minority students consciously or subconsciously reinforce this feeling in those students. Consequently, science career information that may be accessible is not passed on to minority students, or the information will be rendered meaningless by the negative context in which it is presented (George and Dietz, 1971).

Minority counselors (among them many Hispanics) feel that alternative counseling practices are necessary to adequately motivate minority students.

For example, minority counselors urge students to enroll in academic courses. They believe that in the absence of strong home influences, the educational system must work as a surrogate parent, influencing students to prepare for college and success in a variety of fields (George and Dietz, 1971).

Generally speaking, counseling procedures tend to be imbued with contradictions. On one level, counseling procedures are geared toward giving every student the same opportunity; on another, such procedures systematically exclude certain students by denying them needed service and motivation. Counseling practices thus appear to support benign neglect of all but a few students who fit a classic mold. Minority students who have good grades in academic subjects and who are sufficiently motivated to seek science career information fit this mold, and counseling efforts are targeted at these students. However, students who deviate from this mold are directed toward other or less challenging fields of endeavor.

Ironically, when seeking career information, students who have a strong interest in the sciences tend to rely more on parental advice and reading material than on the advice of counselors. On the other hand, the less motivated students tend to seek out a career on their own, relying on peer influence or influences external to the school environment. For both groups, the strongest school-related influence is the teacher, not the counselor (Goldman, 1973).

These facts tend to support statements by counselors that most students have made fairly firm career decisions by the time they reach the counselor. The counselor's role at that point becomes one of channeling the student along a predetermined path. Thus, the minority student is encouraged to pursue a science career only if he has already decided to do so (George and Dietz, 1971).

These practices are also substantiated by Gunning (1972). His data indicate that Hispanic counselors feel that Hispanic students are not recommended as frequently as other students to take advanced science courses or to investigate science careers. Moreover, they feel that even when Hispanic students show an interest in a science career and seek career information along these lines, their backgrounds in science and mathematics courses are not as strong as those of Anglo students. Thus, it is unlikely that Hispanic students will find encouragement to prepare themselves for science careers under the existing system.

Present counseling practices are not structured to pull Hispanic students out of the cycle of career patterns and into less traditional career paths. Rather, they merely serve to reinforce established patterns. Unless the student finds the impetus for breaking the cycle himself or is encouraged to do so by the high school teacher, he/she will not go on to seek a career in the sciences.

Greater efforts are needed for school systems to come to grips with the realities of career counseling for minorities. Counselors must first be made aware of the real-world job opportunities for Hispanics. Secondly, counseling approaches must be altered to accommodate and channel the low-interest student and to open vistas of available career options to students whose social and educational milieus have been severely limited. Thirdly, vocational counseling seems to be geared toward the student who is unlikely to go to college. Vocational counseling must be provided to the college-going student as well. Scott (1977) recommends the following:

1. That channeling minorities into the sciences and other fields which are in need of qualified Hispanics become a priority of secondary school counselors. This means that secondary school counselors must keep abreast of

current and future directions for Hispanics in the scientific and engineering fields.

2. That school systems institute training sessions for counselors whereby they are sensitized to the specialized needs of minority students. These sessions should be designed and directed by minorities and exploit the counseling methods and experiences of minority teachers.

3. That computerized course selection whereby counselors are often excluded from the process of course selection should be minimized. Counselors should be given greater responsibility for counseling.

4. That additional research should be undertaken to investigate the type and quality of counseling services for minority students in integrated schools. Research efforts should also be initiated to examine the short- and long-range effects of counseling services in integrated secondary schools and colleges on the career choices of minority students.

5. That only counselors who show an earnest interest in the welfare of minority students should be permitted to interact in counseling situations with minorities. This would protect minority students from counseling practices which tend to dissuade minorities from entering technical and professional fields (p. 8).

Role of Teachers

The achievement of parity of Hispanics in the technical and professional job markets will require the joint efforts of counselors, students, and teachers.

As indicated above, students generally credit the high school teacher as having the most influence on career choices. Inherent in this conclusion is the fact that students tend to continue in courses of interest which promise personal benefits (e.g., high grades and a base for some future vocation). Of course, the instructional practices of the teacher ultimately determine the degree of influence he/she has on the career choices of students.

Jackson's (1974) data on teachers' perceptions of counseling practices reflected the frequency of interaction between students and teachers

relative to career goals. Despite the potentially strong role teachers can play in the counseling process, they often feel unqualified or lack time for in-depth discussions. On the other hand, teachers often feel excluded from the process and desire greater interaction with counselors regarding student needs.

Jackson (1974) contends that counselors do not appear to be adequately utilizing teachers as resources; nor does the organization of schools provide teachers with the time and resources for involvement in counseling activities. The fact is that prior to the student's senior year, student-counselor interaction with respect to career preparation and selection is rare. Generally, the entry of counselors into the process occurs after the students have made career decisions in conjunction with teachers. Yet, colleges, professional schools, and science industries, which supplement the student's knowledge of necessary preparation and career opportunities, usually interact solely with the counselor, not with the teacher.

An additional function the teacher plays is that of role model. Although frequently an authority figure and a critic of student performance, the instructor must make a special effort to help Hispanic students develop a positive identity within the academic discipline. The instructor as a role model brings the subject matter alive; he/she is a living example of how science and technology are built upon the accumulated knowledge of all persons. Further, the instructor brings a career in science down into the realm of everyday possibility. As opposed to the counselor's neutral ear, the instructor-role model can share with the student the agonies and ecstasies of mastering the subject matter and can challenge the student to utilize his/her potential.

Although it is desirable to expose students to successful Hispanic scientists and/or engineers, non-Hispanic faculty can also be effective role models if they show genuine understanding and appreciation of cultural

differences without patronization. For Hispanic students, non-Hispanic teachers can foster a sense of belonging in the classroom if they exhibit a multicultural perspective and share with other non-Hispanic students the worth and contributions of persons of cultures other than Anglo. This need not take the form of special units or lectures on Hispanic heritage, which often appear artificial or patronizing, but should be intermittent references, stated as a matter of fact.

For instance, for the student of history, Father Junipero Serra almost single-handedly built the California mission system. As a Franciscan priest, whose training better prepared him for church matters, he is only now being recognized as the originator of North America's first mass engineering project. At the age of 56 and laboring under a handicap, he organized one of the first 21 missions in California. A genius at organizing and managing people, a self-taught design engineer and builder, he was to build a line of missions that stretched from San Diego to Monterey. His master plan built, trained, and helped feed an army of locally employed craftsmen, most of whom had to be schooled as carpenters, masons, blacksmiths, saddlers, tailors, millers, and farmers. The California mission system was completed in 1834, but Father Junipero never lived to see his work completed. Yet, his inventive genius, engineering achievement, and management style stand as a monument of dedication of one man's humanity to people (Nick and Reyes, 1978).

Additionally, when a teacher talks of solar energy in a general science class, that individual can easily point to Marcos de la Garza, who patented the first solar energy storage device in the United States. In a day when solar energy storage is an everyday occurrence, why is this point so relevant? De la Garza's invention was patented in 1912 (Nick and Reyes, 1978).

By continually interjecting such tidbits, the teacher accomplishes three things: first, the discipline is spiced with personal and historical vignettes; secondly, Hispanic students see that the teacher is concerned enough to find out about them (many of these points Hispanic students themselves do not know); and finally, a multicultural perspective is encouraged among members of the dominant culture.

Curriculum

With regard to science curriculum, Sears (1974) indicates that almost half of the science and engineering majors enter college with no training in science beyond the second year, or the biology level. He suggests that even college-bound students are not taking full advantage of the high school science curriculum. Although this deficiency does not appear to alter the students' choice of the science major as freshmen, they are beginning college with a limited skill base. This places additional strain on the college for providing backup courses. If these students manage to graduate as science majors, they still fail to be on level with the student who begins his/her preparation with a strong high school background. Sears states the following:

> Rather than relaxing science requirements in secondary schools, curricula should be restructured so that students are required to take rigorous foundation courses which will equip them with the technological and problem-solving skills needed in future careers. In addition, changes must be made in the existing curriculum structure to eliminate tracking systems which bar students from advanced science courses or automatically relegate them to lower-level science courses. (p. 110)

Referring to curriculum design, Young (1976) recommends that the introduction of scientific concepts be more "concrete" rather than "abstract" when Hispanic or other minority students are involved. Young does not wish to imply that minority students are incapable of understanding abstract concepts; he merely wants to indicate that the experiential and educational

backgrounds of many minority students do not lend themselves to these types of mental exercises. He contends that Hispanic and many other minority students become discouraged in traditional science courses because these students do not have the necessary theoretical foundations. Thus, science presented in an abstract context has little meaning to these students. Young, therefore, proposes that a hands-on research project in the area of the student's interest be supervised by the instructor. As the student runs into problems, the instructor can explain the theory which solves the problem and then progress toward the theoretical concept on which the entire research project is based. This approach not only can help students grasp the relevance of theory, but it also offers some immediate reward, a tangible product, for their endeavors. In addition, Young believes this approach is more consistent with the philosophy of science itself. He states the following:

> It is ironic that science, which prides itself on the inductive method, on first observing and collecting empirical data and then drawing conclusions or theories, is most often taught by the deductive method. The student is immersed in theory before seeing its operation in the concrete. Although many engineering schools have greatly utilized experiential learning through cooperative education programs, the opportunity to apply and practice theories usually comes later in the student's college career. We propose that from the beginning a student be given a tangible project in which to explore scientific concepts. (p. 46)

Such an approach may obviate middle-class biases and expectations that cause teachers to label students as slow or disinterested in science. Reisman (1972) points out that a pupil may be slow because he/she is extremely careful, meticulous, or cautious, because of his/her refusal to generalize readily, or because he/she may not understand a concept unless something physical (e.g., hand manipulation) is tried. This points to teaching and learning modes congruent with the attributes of subcultural groups which can heighten motivation and maximize potential.

A Comprehensive Model for Intervention

Unlike some fields where preparation may begin in the latter stages of academic training, preparation for careers in science and technology must begin early with the mastering of specific basic skills. It is often important that training be uninterrupted and continue through the mastery of more advanced skills and the attainment of credentials.

Scott (1977) outlines three conditions which are crucial to this process with respect to student needs: the attainment of fundamental skills (Condition 1); development of a long-range career plan and job availability (Condition 2); and constant reinforcement, motivation and counseling regarding academic and professional requisites (Condition 3). For Hispanics in particular, and other minorities in general, to reach the ultimate goal of employment in the science fields, these conditions must be met.

Past attempts to provide these conditions for Hispanics have been haphazard at best. Regional intervention programs have been spotty and have not sought to address a condition characterized by broad and benign neglect. Development of programs to reverse the patterns of minority participation in the sciences must include strategies which satisfy each of these interlocking conditions.

Table 4 depicts a comprehensive model for corrective action developed by Scott (1977). The model is quite useful for Hispanic entry into and growth within technological fields. It is generic in nature, specifically designed for career planning, and applicable to numerous disciplines and nontraditional occupations. The model emphasizes the participation and re-education of administrators, teachers, counselors, and state, military, and industrial agencies. With some modification, the model can be applied to the secondary and post-secondary institutional environment.

The model presupposes that the student needs inherent in Condition One are met. It also serves to reinforce student needs on a level concomitant with long-term career goals. Beginning with Condition Two, any intervention tactic must stress nontraditional careers for Hispanics. If a student has the necessary personal, family, and financial support and is able to obtain the normal academic support from present and future educational experience, he/she may progress through the career selection/preparation process with little difficulty. Without this minimal support, additional inputs are needed.

The assumptions underlying the model are as follows:

1. The majority of Hispanic students do not fit the classic mold described above; hence, additional inputs are required.

2. Educational administrators, teachers, counselors, industry and government agencies should provide the major inputs for satisfying student needs.

3. Each of the above input sources must become aware of present and projected employment needs and areas of underrepresentation for Hispanics. It is very important that they begin thinking in terms of non-traditional careers for Hispanics and other minorities.

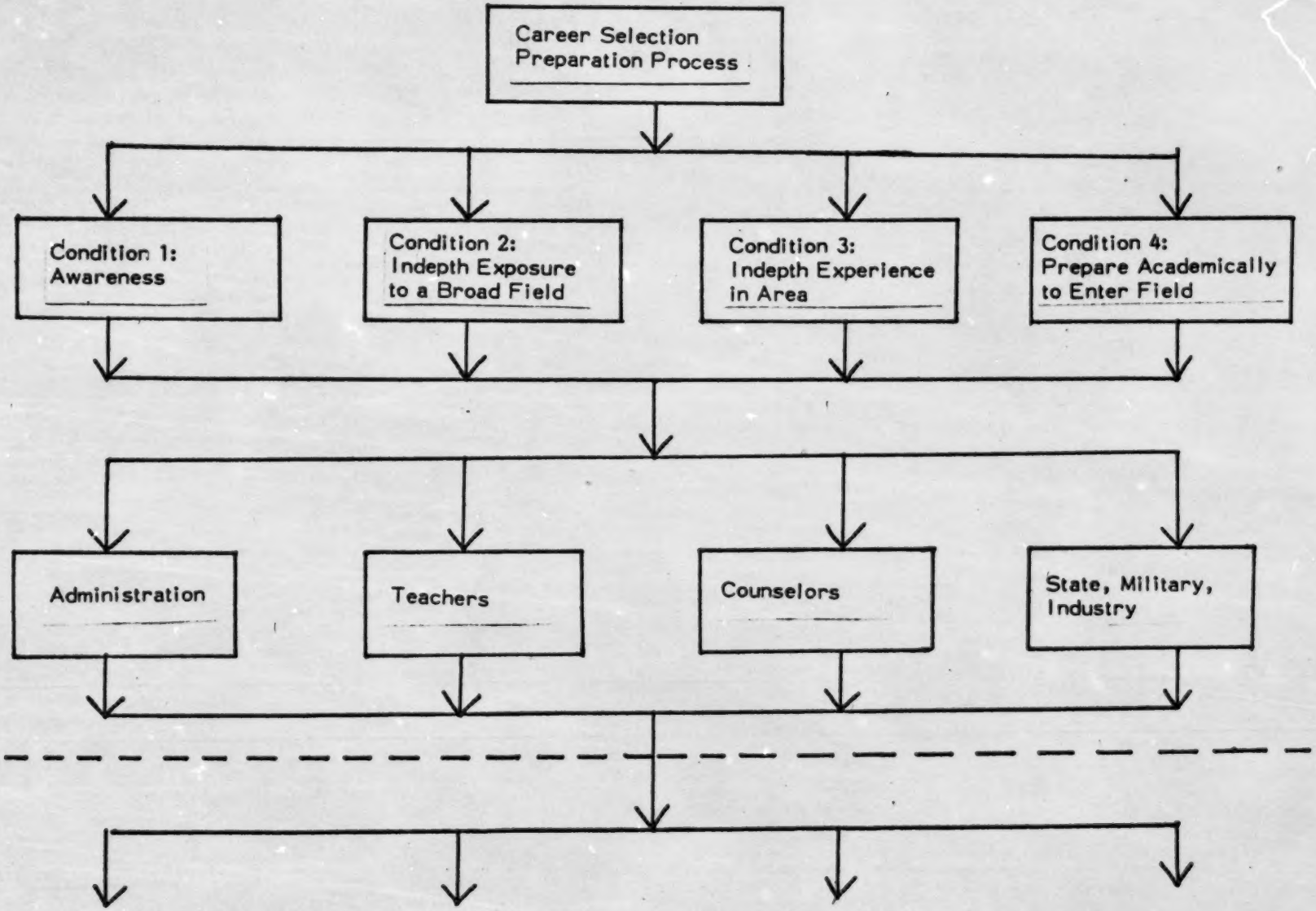
4. Each, within his/her own sphere and through interactive methods, must begin corrective action.

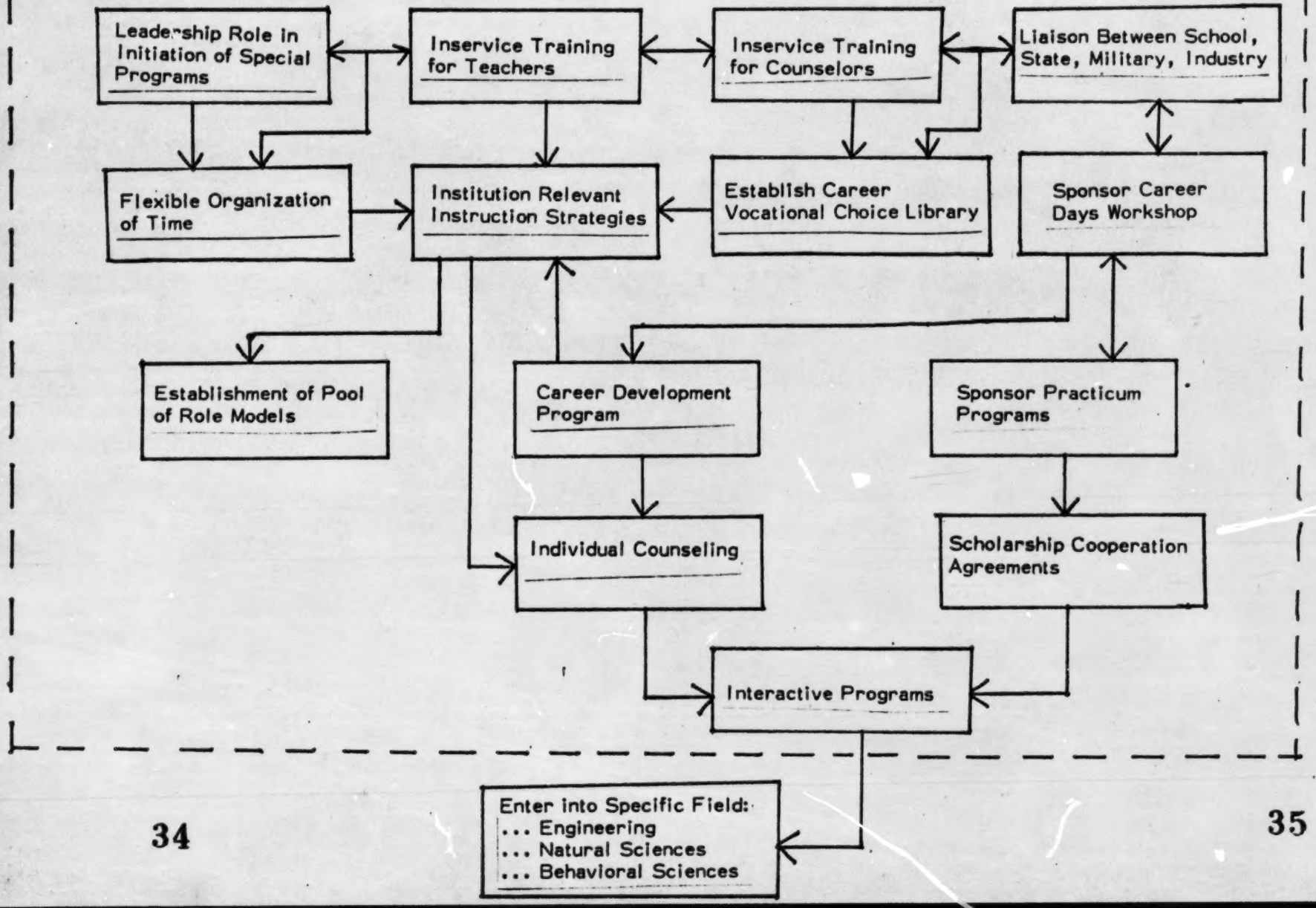
5. The use of role models is germane to the development of non-traditional career paths for Hispanics.
(Scott, 1977, p. 14)

Referring to the implications found in the model, Scott (1977) states the following:

> Inherent in the model is the need to alter present responsibilities of teacher, to include more significant participation in the counseling process. Changes are in order so that school support is allotted the time and resources necessary to impact student choices. Also, vocational training of teachers is necessary. Greater involvement of government agencies and industries is needed, not only in providing employment opportunities, but also in educating teachers and counselors and in providing experience and incentives

Table 4. Career Selection Interventions




Leadership Role in Initiation of Special Programs
Inservice Training for Teachers
Inservice Training for Counselors
Liaison Between School, State, Military, Industry
Flexible Organization of Time
Institution Relevant Instruction Strategies
Establish Career Vocational Choice Library
Sponsor Career Days Workshop
Establishment of Pool of Role Models
Career Development Program
Sponsor Practicum Programs
Individual Counseling
Scholarship Cooperation Agreements
Interactive Programs
Enter into Specific Field:
... Engineering
... Natural Sciences
... Behavioral Sciences

> for students. Implicit in any steps taken, however, is a cooperative effort among the essential sources of input. (p. 16)

The model does not presuppose a particular intervention point with regard to grade or age level. It is quite possible that some form of intervention can occur at any age level. However, in consideration of the need to shape career tendencies early enough to affect the high school curriculum of a student, Conditions 1 through 3 of the student needs component of the model should be implemented no later than the grade level preceding the one in which the student must decide upon his/her high school curriculum track (i.e., college preparatory, academic, or general-vocational). At that time, students must be made aware of the diverse careers in science.

In the first phase, programs, similar to existing career days but focusing primarily on science and technical careers, must be developed. Such a concerted effort must be made because science teachers and counselors may be limited in their knowledge of such careers and because students often simply perceive "scientists" as peculiar people. Science career days can be structured to convey a broader knowledge of potential science careers to students, teachers, and counselors. Additionally, such career efforts must seek to foster among teachers, counselors, industry, and students the kind of interaction exemplified in the model (Toplin, 1971).

RECOMMENDATIONS

The following recommendations have been grouped and focused at three different levels of education: precollegiate level (elementary and secondary schools), collegiate level, and graduate level. A fourth group, more general, more policy-oriented, and more national in scope, is aimed at responsible governmental agencies and professional and other organizations. In the

discussion of educational needs, the authors have addressed themselves both to specific types of programs as well as to characteristics believed to be generally useful. The authors use a variety of sources in compiling these recommendations: Hispanic scientists and engineers were interviewed, students were surveyed, and the literature was scanned. The recommendations are based both on what appears to work and on what appears to be worth trying. Evidence is minimal because few specific techniques have been tested. The gaps in available information constitute license for the authors to stipulate and suggest. At no point do the authors imply that these recommendations have been secured from existing models.

Precollegiate Program Needs

Most Hispanic students never get to college, so education, recruitment, and counseling needs must be met at the precollegiate level if the pool of Hispanic students from which scientists, technologists, and engineers may be drawn is to be increased. Two themes have run so consistently through the research literature that they demand attention in any set of recommendations. First, the need among Hispanic scientists and educators is in the area of applied science, for trained personnel who can assist Hispanic communities in solving real problems. Second, we hear reiterated the need for counseling, not only for students, but also for their teachers, counselors, and families, on the utility of science and the employment opportunities in scientific and technical fields. The school systems themselves have primary responsibility in these areas, but they are entitled to advice and assistance from public and private funding agencies and appropriate professional organizations.

With regard to precollegiate levels of education, then, the following are recommended:

1. Public school science curriculums organized around the science of everyday experiences. Everyday experiences in science are essential for elementary level children. In this manner, science becomes something real and concrete. In addition, this same "everyday experience" approach can be quite useful at the secondary level. At the secondary level, the need is to capture interest, to stir an adolescent to feel that there are possibilities for further exploration into these areas. Courses can focus on the environmental aspects of the daily life of the particular group of students, with special attention paid to the historical and contemporary living situations of Hispanic people. For example, whole courses could focus on the ecology of a rural environment or an urban environment, and sections could be devoted to nutrition, to natural resource development and its effects on the natural and human environments, and to the technologies used to effect resource development. Outreach components of such courses could be developed to involve members of the community in the learning process, and these would most likely be successful where specific decisions about scientific and technical matters make an increased science literacy more important. This approach can be combined with standard programs emphasizing hands-on laboratory, experience-based instruction, such as Science Curriculum Improvement Study (SCIS), Science--A Process Approach (SAPA), Elementary Science Study (ESS), etc. On the secondary level it can be realized in work-study situations.

2. Bilingual science and mathematics instruction. Bilingual techniques must be used where language retention is maximal, particularly at the elementary levels. Bilingual science and mathematics instruction depends on the production of curriculum and Spanish-language scientific and technical dictionaries. These will have to be produced through the cooperation of scholars and members of the community. The bilingual education must not,

however, be just a matter of translation, but one which involves genuine respect for the Hispanic culture and which takes into account the learner characteristics of Hispanic students. Teacher-training institutions must give attention, in both pre-service and in-service training, to attitudinal as well as linguistic matters.

3. Concentrated attention to mathematical deficiencies. Mathematics competence was identified as absolutely essential. At present, lack of mathematical skills constitutes a primary barrier to general and science-specific education. Individualized mathematics instruction and/or tutoring should be tried in a number of different settings. Although they may be particularly useful for beginning courses in general mathematics, algebra, and geometry, they can later be adapted to trigonometry, calculus, etc. They may be especially useful when combined with tutoring, particularly when students act as tutors. Standardized programs or programs developed for a particular situation can be used with expectations for improvement.

4. Incorporation of ethnoscience. Hime (1974) relates the outstanding experience of some teachers who used an ethnoscientific approach to teach high school science to the Navajo. He recommends this approach in teaching science to American Indian children in other tribal areas. A similar approach may be used in areas of the United States where large Hispanic concentrations exist. This is particularly true where traditional modes of Hispanic scientific inquiry are still functional and operative and where Hispanic specialists (curanderos, herbalists, astronomers, healers, diagnosticians, etc.) can take part in the sharing of knowledge with children. Programs should draw heavily on the knowledge of members of the community when their knowledge can be shared (for example, when it is not specialized knowledge meant only for clan initiates or healers-in-training) and on the "discovery" skills of the students themselves. Utilization of these materials and persons should not be restricted

only to predominantly Hispanic schools, for they can be equally instructive to non-Hispanics and can contribute also to their respect for Hispanic culture and traditions. Such programs would require specialized teacher training both in ethnoscience content and methodology. In addition, the much desired regional adaptations of general methodologies would have the added benefit of involving the local community in preparation of materials and activities for the courses and of raising community appreciation of the need for science and mathematics instruction.

5. Taking advantage of working experience. Among college students committed to scientific and technical careers, practical experience, usually as a paid worker, is often the basis of a career decision. For many students, that experience may be post-secondary. Secondary school science educators should seek opportunities to provide meaningful practical exposure to the scientific and technical world of work.

6. Academic and career counseling. According to many of the research studies reviewed, many Hispanic students, in or out of science, feel that they have been their own counselors. Better career information, associated especially with academic counseling and the course selection process, could only be a plus. These should be separated from personal and especially from disciplinary counseling and preferably vested in a Hispanic counselor or other person with whom Hispanic students can readily relate. Career counseling could usefully be combined with work-study programs developed in the community and with summer career health/science enrichment programs available to students through universities or efforts funded by businesses and foundations.

Needs at the Collegiate Level

Recent research has revealed two valid generalizations which have special significance for collegiate-level programs to recruit Hispanics to scientific and technical fields. First, it seems that special programs, funded and organized to attract and support minority students in nontraditional fields, do work and are responsible for a large proportion of the minority (especially Hispanic and Black) enrollments in health and engineering. Second, on-the-job experience--in the army, in hospitals, etc.--seems to be an important career determinant. Efforts to increase the number of Hispanics entering nontraditional fields should capitalize on this knowledge.

The recommendations in this section are aimed toward the various agencies which have supported or could support special programs and toward the higher education institutions that have large concentrations of Hispanic students and who must take on continuing responsibility for institutionalizing and supporting special programs. Among those, the institutions of higher education with large percentages of Hispanics in their enrollment have special needs and missions. These recommendations should be heeded also by appropriate professional associations. They are as follow:

1. Existing special programs in the health sciences and engineering deserve continued support. Programs that have been made available to Hispanic students have amply illustrated that it is possible to attract students to nontraditional careers even in the absence of any role models or previous acquaintance with the profession, provided the programs are well designed, well staffed, and amply funded. They must not be allowed to die as so many special programs for minorities have, just when they are beginning to achieve their promise. This means that (1) federal agencies, private foundations, and corporations must

maintain an adequate level of support and (2) the higher education institutions must, themselves, assume responsibility for continuing the experience their staffs have acquired.

2. Special programs must be established in fields where they do not now exist--in the physical sciences, in mathematics, in resources development. Existing programs for Hispanics in science and technology are almost all in the health sciences and engineering, where they have been stimulated and supported by the National Institute of Health (NIH) and by selected private foundations and corporations. Other federal agencies that have responsibility in these areas (such as the National Science Foundation, U.S. Department of Energy, U.S. Department of Agriculture, Environmental Protection Agency, et al.) must strengthen their roles. Private foundations and corporations in related industries must do their part, and professional associations must be advocates, advisors, and assistants.

As discussed on the precollegiate level above, the kinds of techniques that show the greatest promise of success must be integrated into these programs. Most importantly, meaningful work-study arrangements, culturally sensitive instruction and materials, mathematics anxiety therapy, and hands-on and individualized instruction must be instituted. Cooperative, intern, and teaching assistant components should be structured into programs wherever possible, and they should attempt to develop affiliation on a regular basis with business, industry, government, state, and local agency projects in the field to achieve maximum student identification with career options and work in the "real world." Like most successful biomedical sciences programs, mathematics and physical sciences programs should take a team-based approach and focus on applications. In the physical sciences programs, mathematics instruction should be adapted for use in the specific field and applied, whenever possible, to real problems

ordinarily encountered in the field. Physical sciences programs should also be directed toward problem-solving, with heavy emphasis on contemporary Hispanic educational, resource, and economic development needs. In natural resources and conservation fields, the most needed and least represented in program development, new programs should be based on Hispanic needs and problem-solving in applied situations.

3. Greater efforts should be directed at identifying and recruiting Hispanic students for participation in special programs for minorities in scientific and technical fields. Post-secondary certificate and pre-collegiate high school programs should be undertaken as a joint effort of post-secondary institutions with special programs and local secondary institutions which serve Hispanic populations. The target groups are Hispanic adults with a gap between high school certification and proposed entry into collegiate work and a high school student population with a demonstrated readiness for advanced work.

4. Teacher-training and counselor-training institutions must increase their production of graduates and in-service trainees who can tackle science and math inadequacies of Hispanic students at the precollegiate level. Teacher and counselor training programs involved in preparation and in-service training programs of personnel for Hispanic communities must increase their emphasis on the utility and importance of mathematics and science. They must develop knowledge and instill cultural sensitivity in trainees to make them effective helpers in Hispanic communities. Training should take the form of a special emphasis in the general education degree or of a special program for minority/ Hispanic students. Programs should be directed also to the "science literacy" of the community as well as to general teacher education. Higher education institutions must be joined in this task by relevant professional associations

(National Science Teachers Association, American Personnel and Guidance Association, etc.).

Needs at the Graduate and Professional Level

Minority scientists and educators know from experience and from other explorations of the problem that the minority science students, including Hispanics, who enroll in graduate programs are, by definition, a specially self-selected, motivated, and able lot. In short, to have overcome so many barriers and to have gotten that far, they necessarily possess all of the usual attributes of academic success plus some others. At this level they may well need, however, four kinds of help: (1) financial support that comes from minimum economic guarantees, (2) psychological support from a sufficient number of fellow Hispanic students, as well as staff or community contacts to offset the feelings of isolation experienced by "the special few," (3) non-patronizing remedial assistance if it is necessary and asked for, and sometimes (4) special additional course content that makes the professional or graduate training pertinent to community needs. With this in mind, the following is recommended for these students:

1. Graduate and professional institutions seeking to enroll Hispanic students must meet some minimal requirements. They must recruit in sufficient numbers to allow the formation of a community of Hispanic students large enough to avoid isolation and alienation and to provide a mutually supportive atmosphere. The institutions must make every effort to have on their faculties and/or staff advisors who are themselves Hispanics. They must look carefully at student financial needs, including family obligations, and try to put together available funds into an adequate financial package. They must review academic regulations and requirements and make sure they admit late starters and permit dropping in and out as financial and family obligations may require.

2. Adequate financial aid must be available to graduate students. Existing federal educational aid programs and other private programs underscore the great need for support of undergraduate students. If, however, we seek to train significant numbers of Hispanic American graduates in specialized fields, adequate financial support at the graduate level could be a major incentive. Hispanic communities and organizations must help funding agencies to identify areas and kinds of needs. Professional associations and graduate departments are perhaps best able to counsel on the fitness of existing programs for Hispanic needs. All fellowship programs must be reviewed for provisions which would prohibit Hispanics from returning to school after employment, marriage and children, military service, etc., for these are the characteristics of many Hispanics currently in these programs. In funded programs which seek to impact on the long-range needs of Hispanic peoples, funding priority should be given to those students preparing to work in institutions that serve Hispanics or to train other Hispanics. Financial incentives, in fellowship receipt or loan repayment, should be tied to a period of service in or for the Hispanic community.

3. Some graduate and professional programs should conscientiously include a multicultural focus, specifically a Hispanic focus in their training. All professionals who intend to work with Hispanic communities--physicians, nurses, and other health professionals; engineers, natural resource specialists, agricultural extension workers, teachers, architects, etc.--whether they are Hispanic or not, need more information about and understanding of cultural variations, traditions, and values than are normally a part of professional training. The successful transfer of technology and knowledge must be governed by an understanding of existing cultural values and indigenous scientific and technical traditions. In this area, where scholarly information

must impinge on curriculum development and course content, the professional associations are the groups to take responsibility.

4. Post-baccalaureate programs for Hispanic students should be developed by graduate institutions. These should be aimed at removing the deficiencies of an inadequate or other-field directed baccalaureate degree and preparing the student for graduate or professional training in science and other technical fields.

Needs to be Addressed Outside Educational Institutions

There are a number of needs--for information, coordination, and cooperation--that are best addressed by organizations of Hispanic educators, engineers, and scientists working with pertinent professional, scientific, and educational associations. There are also major policy issues related to the increased participation of Hispanics in scientific, technical, and biomedical fields where cooperative and advocacy roles with state and federal agencies must be undertaken by these various organizations. Recommendations for these groups are:

1. A clearinghouse for information on mathematics and science needs and programs in the Hispanic communities should be established and maintained. The exchange of information and contacts thereby established will constitute a network that can help to develop ties among Hispanic scientists, engineers, and others sharing concern for the science and technical education of Hispanic peoples, and to encourage the participation of Hispanic professionals in national scientific and engineering societies.

2. A consortium of persons in professional associations, federal agencies, and programs that have interests and activities bearing on Hispanic science education and manpower development should be established. Through

their sharing of information and contacts, they could achieve program cooperation and coordination which would enhance their collection effort. Potential participants would include persons from the American Association for the Advancement of Science, the National Academy Committee on Minorities in Engineering, the National Science Foundation, the National Institute of Health, the American Chemical Society, and the American Association of Junior and Community Colleges.

3. A funding guidelines review should be undertaken by private foundations and federal funding agencies to determine priorities and needs for Hispanic science education and manpower development and to examine the applicability of present guidelines to Hispanic American programs and needs. Funding organizations and agencies such as the Fund for the Improvement of Post-Secondary Education, the National Institute of Health, the National Science Foundation, as well as private foundations with minority programs should be involved in such a review.

4. Non-institutionally based programs, or satellite programs, should be established to reach populations not ordinarily served by educational institutions. For instance, rural adult science education and literacy programs might be developed by the Department of Agriculture Extension Programs.

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